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(54) Telecommunication system

(57) A telecommunication system includes a number of radio base stations 5 connected to a telephone network 1, the base stations forming a link to the network for a number of cordless telephones 7. Each base station 5 determines which, within a number of predetermined signal strength bands, the signal strength of a signal produced by a cordless telephone 7 and received by the base station 5 lies. If the received signal strength is in the highest signal band, the base station 5 sets up a link between the cordless telephone 7 and the telephone network 1. If the received signal strength lies in a lower band, the base station 5 stores an indication of the signal, and scans through the communication channels available between the base station 5 and the cordless telephones 7 to determine whether a new incoming signal lies in the highest signal band, or whether by increasing the band rank of a stored signal, the highest signal band is reached.

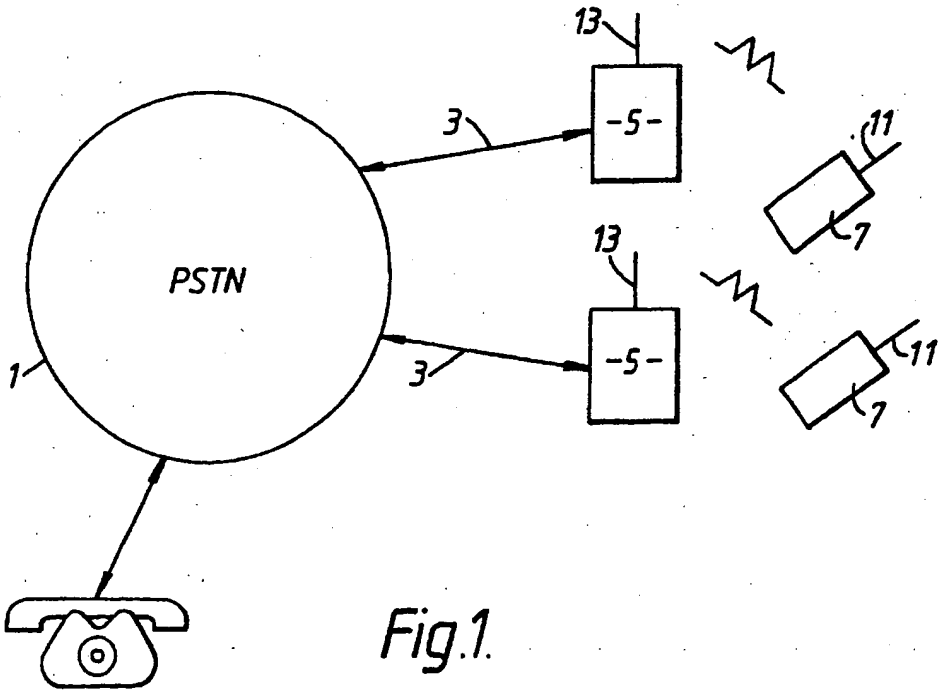

Fig.1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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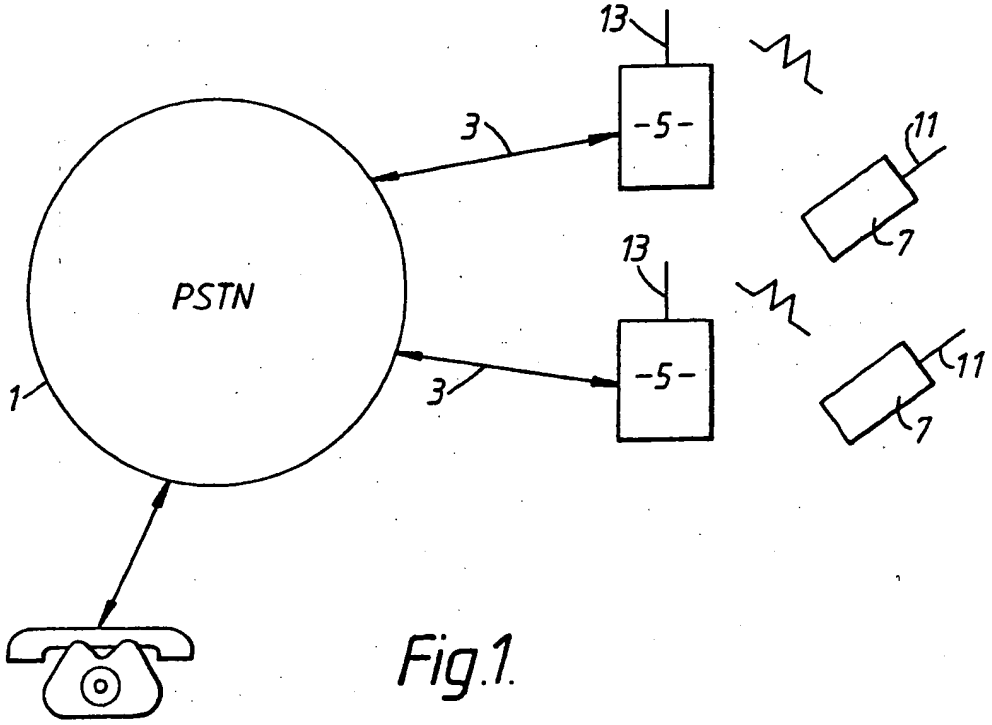

Fig.1.

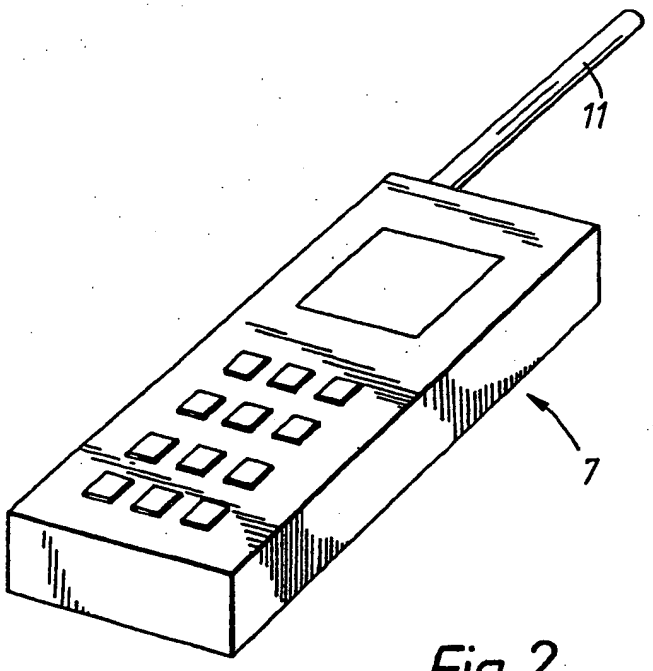

Fig.2.

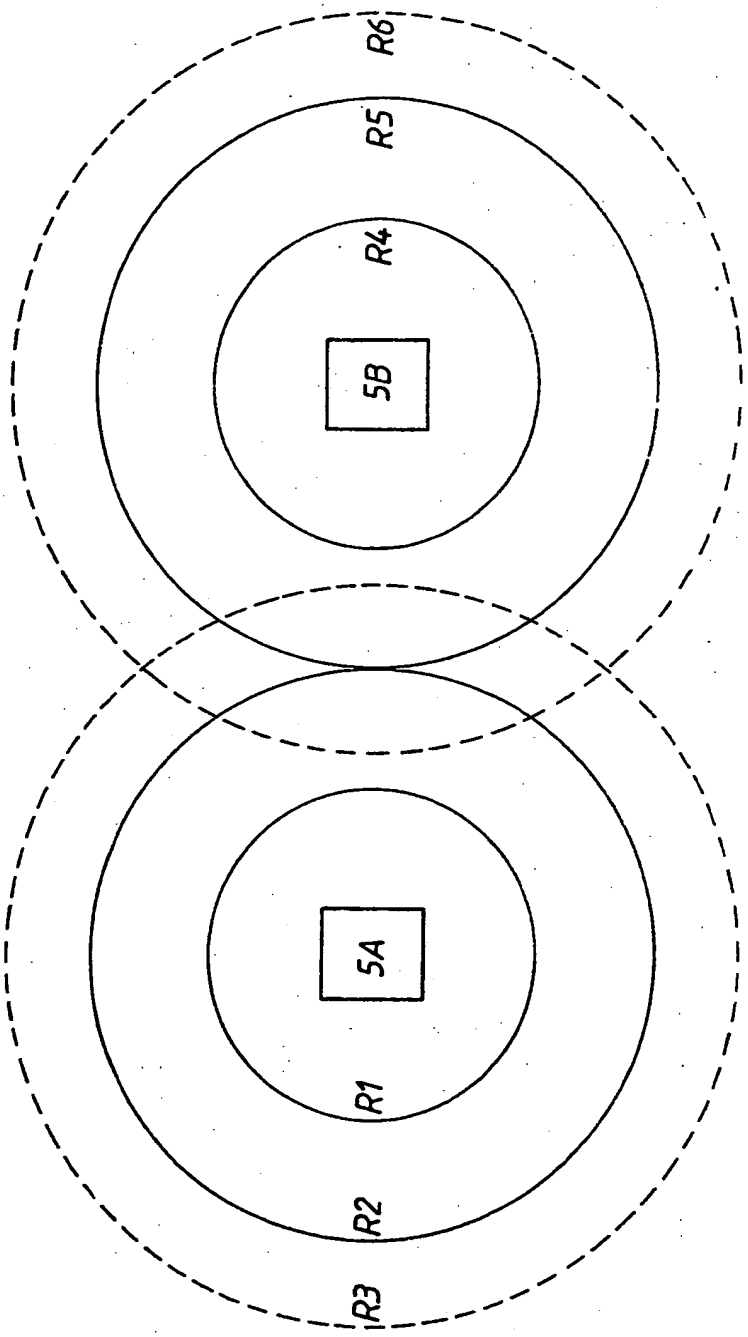

Fig.3.

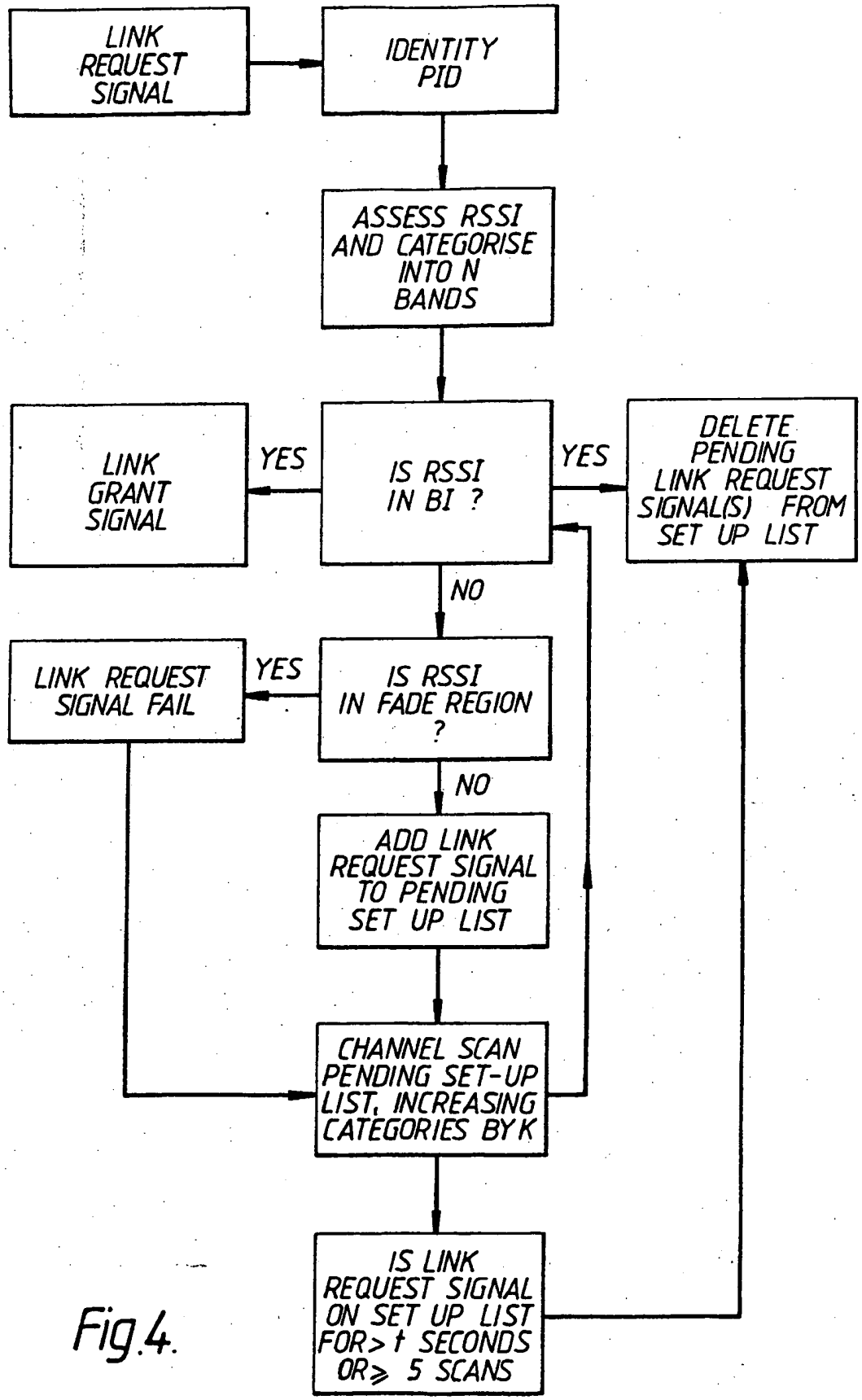
LINK REQUEST SIGNAL
IDENTITY PID
ASSESS RSSI AND CATEGORISE INTO N BANDS
IS RSSI IN BI ?
YES
LINK GRANT SIGNAL
YES
DELETE PENDING LINK REQUEST SIGNAL(S) FROM SET UP LIST
NO
IS RSSI IN FADE REGION ?
YES
LINK REQUEST SIGNAL FAIL
NO
ADD LINK REQUEST SIGNAL TO PENDING SET UP LIST
CHANNEL SCAN PENDING SET-UP LIST, INCREASING CATEGORIES BY K
IS LINK REQUEST SIGNAL ON SET UP LIST FOR > t SECONDS OR ≥ 5 SCANS

Fig.4.

TELECOMMUNICATION SYSTEM

This invention relates to a telecommunication system and has particular, although not exclusive, relevance to telecommunication systems including cordless telephones.

The so-called CT2 cordless telephone system is a system wherein possessors of suitable telephone handsets can register their handsets with one or more service providers, the memory of the handset then being encoded with the appropriate identification code (LID) for that service. Such registered handsets can then be used to make outgoing calls through suitably located radio base stations to a telephone network, these base stations generally being located in public places, for example railway stations. Such a telecommunication system is hereinafter described as "a telecommunication system of the type specified".

When the user uses the handset to request that a call be made, the handset transmits a signal, the LINK REQUEST signal including data fields incorporating an identity number (PID) identifying the particular handset, together with the LID of the service provider. At some locations, such as railway stations, a service provider may install more than one radio base station in order to

provide sufficient carrier capability. In the CT2 system all base stations belonging to a given service provider will respond to all received signals from handsets transmitting the appropriate LID for that service. This creates difficulties however where there are two or more base stations having overlapping coverage. Where such base stations detect a LINK REQUEST signal from a handset, it is entirely random which base station will respond to the LINK REQUEST signal. Thus, the base station receiving the weakest signal may respond, this resulting in a poor quality signal telephone link for the user which could have been improved if a base station receiving a stronger signal from the handset had responded to the LINK REQUEST signal.

In U.K. Patent Application GB-2241134A there is described a telecommunication system of the type specified, in which each base station compares the received signal strength (RSSI) from a handset with a predetermined stored threshold signal level before setting up a link. If the RSSI is above the predetermined signal level, the base station immediately attempts to set up a link. If, however, the RSSI is below the threshold level, the identity of the handset is stored and the base station will only set up a link

if it receives a subsequent request from the same handset.

It is an object of the present invention to provide a telecommunication system of the type specified in which the above problem of base stations having overlapping coverage is at least alleviated, the system having greater sensitivity than known telecommunication systems.

According to a first aspect of the present invention there is provided a telecommunication system including at least two base stations for communication with a telephone network, and a plurality of portable telecommunication apparatus arranged to communicate with the base stations through a plurality of communication channels, each base station having means for determining which in a plurality of signal strength bands the signal strength of a signal produced by a portable telecommunication apparatus and received by the base station lies, means for linking the portable telecommunication apparatus to the telephone network if the strength of the received signal lies within the strongest signal strength band, or otherwise recording an indication of the received signal in a pending received signal list, means for scanning through the communication channels for new signals from other of the

portable telecommunication apparatus and recorded signals on the list, means for periodically increasing the band rank in which the recorded signals lie until they reach the highest signal strength band and then linking the originating telecommunication apparatus to the telephone network.

According to a second aspect of the present invention there is provided a base station for communication with a telephone network and with a plurality of portable telecommunication apparatus through a corresponding plurality of communication channels, the base station having means for determining which within a plurality of signal strength bands the signal strength of a signal produced by the portable telecommunication apparatus and received by the base station lies, means for linking the portable telecommunication apparatus to the telephone network if the strength of the received signal lies within the strongest signal strength band, or otherwise recording an indication of the received signal in a pending received signal list, means for scanning through the communication channels for new signals from the portable telecommunication apparatus and recorded signals in the pending received signal list, means for periodically increasing the band rank in which the recorded signals lie until they reach the highest signal

band and then linking the originating telecommunication apparatus to the telephone network.

One telecommunication system, together with a base station for use in the system, in accordance with an embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of the telecommunication system;

Figure 2 illustrates schematically a handset used in the system of Figure 1 on an enlarged scale and in more detail;

Figure 3 is a schematic diagram indicating the range of each base station incorporated in the system shown in Figure 1, and

Figure 4 is a flow chart illustrating the operation of each base station incorporated in the system of Figure 1.

Referring firstly to Figure 1, the telecommunication system includes a central switching network 1, this being typically a public switched telephone network

(PSTN), although in the future the network 1 may also be an integrated servives digital network (ISDN). The network 1 is connected via suitable cabling 3 which may be either hard wire or optical fibre, or by an rf link, to a number of base stations 5 located at, for example, railway stations or other public places. Only two such base stations 5 are shown in Figure 1 for the sake of clarity, although it will be appreciated that a great number of such base stations will normally be connected to any given network 1. Each base station 5 is intended to service a great number of portable hand sets 7 carried by users of the system, only two such handsets being shown in Figure 1. The system is designed to be in accordance with the European Telecommunications Standards Institute interim standard I-ETS 300 131, incorporated herein by reference, to which reference may be had for further details and regulatory restrictions of the system.

Referring now also to Figure 2, each handset 7 includes a memory (not shown) in which is programmed the portable identification number (PID), constituted by 27 bits, this number uniquely identifying the handset. The memory also is programmed with at least one 16 bit quantity, the LID, each ID identifying a service with which the user of the handset is registered.

In order to make a call, the user enters the required remote telephone number on the keypad 9 of the handset 7. This causes the antenna 11 of the handset 7 to transmit an rf signal which will be detected by the antennae 13 of all the base stations 5 within the range of the handset 7. The signal transmitted by the antenna 11 is the so-called LINK REQUEST signal including the PID and LID. The LINK REQUEST signal is sent out from the handset 7 in a burst mode transmission mode known as MUX 3. Further details of this signal configuration is described in European Patent Application No. 90902643.7. In this mode each handset 7 transmits continuously for 10ms and then receives continuously for 4ms. This cycle repeats for at least some 750ms, after which time the handset 7 may try transmitting on a different channel, or until a base station 5 responds, or until the expiry of a time limit set by a timer (not shown) in the handset 7 at 5 seconds, whichever occurs sooner as will be described in more detail hereafter. On expiry of the time limit of 5 seconds, the handset link set up attempt will be regarded as failed and the user must redial. When each base station 5 within the range of the handset 7 detects the LINK REQUEST signal it will process the LINK REQUEST signal, to determine from the LID whether the handset 7 is registered with the service serviced by that base station 5.

Turning now also to Figure 3, in some locations such as railway stations, it is likely that the base stations 5 will have overlapping range. Thus, in the example shown in Figure 3, base station 5A will have the overall signal range R1+R2+R3, whilst base station 5B will have the range R4+R5+R6, where:

R1 and R4 are the annular regions of RSSI lying within a first band for base stations 5A and 5B respectively;

R2 and R5 are the annular regions of RSSI lying within a second band for base stations 5A and 5B respectively, these signal strengths being less than a first threshold signal strength for the two base stations 5A,5B;

R3 and R6 are annular regions corresponding to the fade regions for base stations 5A and 5B respectively, for RSSI of greater than the sensitivity threshold for the two base stations 5A,5B, but where good quality communication with each base station may not necessarily be maintained from a handset.

It will be appreciated that generally the ranges R1,R2,R3,R4,R5,R6 will be terms of signal strength not distance. Thus the nearest or furthest base station to any particular handset 7 will not necessarily be in terms of geographical distance, but in terms of "rf distance". A base station that is geographically close to a handset may, therefore, measure a RSSI which is

lower than that of a base station which is more distant from the handset if there are more obstacles between the hand set and the closer base station than between the handset and the more distant base station.

In use of the system when a handset 7 transmits a LINK REQUEST signal, all base stations 5 which detect the signal will follow the procedure set out in the flow diagram shown in Figure 4. On receipt of a LINK REQUEST signal, each base station 5 within the range of the signal will assess the signal's RSSI. Each base station will also note the handset identity by means of the PID within the signal.

The base station 5 will then categorise the RSSI into N-bands, where N = 2 in the example described. If the categorisation of the signal is in band B1 corresponding to the ranges R1 and R4 in Figure 3, that is the highest signal strength band, then the base station 5 will respond immediately to the LINK REQUEST signal and transmit a LINK GRANT signal to the handset 7, this containing the handset PID and also a random number in the LID field, known as the link reference. The base station 5 then continues with the CT2 link set up protocol agreed by the Common Air Interface (CAI) Executive, waiting for a confirmatory handshake response

from the handset 7. On receiving a handshake response from the correct handset 7, the link is established, and the pending set-up list is cleared. The base station will then establish the link between the handset 7 and the central switching network 1 to enable the user of the handset 7 to communicate through the central switching network 1 to a remote telephone, for example as shown at 15 in Figure 1.

If the RSSI are in the fade margin regions, corresponding to the ranges R3 and R6 in Figure 3, the base station will ignore the LINK REQUEST signal. This prevents the base station attempting to set up calls on the basis of very weak signal strengths. Thus a user does not get the impression of poor quality signal links for the system.

If however, the RSSI is in an intermediate band, i.e. B2 corresponding to the ranges R2 and R5 in Figure 3 in the particular example illustrated in Figure 3, then the base station 5 must scan through the available communication channels which are available to the handsets 7 and will add the handset 7 identified by the PID to a list of pending set-ups within the base station's memory, up to a maximum predetermined number of pending set-ups preprogrammed in the base station 5.

This effective time delay then gives another base station 5 the opportunity to respond to the handset 7 if the other base station 5 receives a higher strength LINK REQUEST signal from the handset 7. If, however, the original base station 5 then sees a LINK REQUEST signal for which the signal categorisation is in the highest signal band B1, then the base station 5 will respond immediately, deleting all pending set-ups in the list.

As the base station 5 continues to channel scan, further LINK REQUEST signals of RSSI greater than the lower threshold limit will be picked up from other handsets 7. If the LINK REQUEST signals are from handsets 7 already in the pending set-up list then the existing signal categorisations are arranged to be raised by K levels of categorisation. If this then raises the categorisation of the signal into the highest rank signal band B1, then the base station 5 will transmit a LINK GRANT signal to the handset 7 and set up the call through the network 1, deleting the pending set-up list. If, on the other hand, none of the stored LINK REQUEST signals have reached the highest level signal, the base station 5 will continue to scan through the channels.

The base stations 5 also include a mechanism for deleting pending LINK REQUEST signals in the pending

set-up list after a certain time. This will generally be within the 5 second timer limit of the handsets 3 previously mentioned. Alternatively, deletion of a pending LINK REQUEST signal may take place after the pending signal has been scanned a predetermined number of times.

Each handset 7 will also include a timer effective to set a predetermined time limit after which the handset 7 is free to stop transmitting, and to choose a new channel on which to repeat the procedure. This is typically set at 750ms.

It is found that it is possible for a base station 5 to scan through all the available channels within one handset transmit cycle of 750ms, even in the most dense traffic situation. The channel number on which the base station 5 sees a LINK REQUEST message is not relevant. Since a handset will transmit for 750ms on one channel prior to trying another channel, it depends on how late in a 750ms cycle a LINK REQUEST signal is detected by the base station, and thus how long the base station response is delayed. Thus, there is no need for the base station 7 to store the channel on which a LINK REQUEST signal is detected by the base station.

It will be appreciated that whilst in the particular example described herebefore, by way of example, the base stations 5 only check the LID within the LINK REQUEST signals. In some systems, however, the base stations may check both the LID and PID.

It will also be appreciated that the problem of allocation of base stations 5 to outgoing calls from the handsets 7, is achieved by amendment to the software in the base stations. Thus no change to the handsets 7 is required. Such a modification to the software in the base stations will be applicable to all forms of base stations used in the CT2 cordless telephone system. Account must, however, be taken of the differing rf systems involved and any passive or other combiners used in the base stations 5. The time taken to scan through the channels leading to the link set-up response time will not be significantly effected from the perspective of the user. The user will, however, get a better impression of the system due to the optimum signal strengths link-up being chosen.

It will also be seen that the implementation of the above system will have a low processing overhead and can be realistically implemented in a small amount of code on an 8 bit microcontroller.

CLAIMS

1. A telecommunication system including at least two base stations for communication with a telephone network, and a plurality of portable telecommunication apparatus arranged to communicate with the base stations through a plurality of communication channels, each base station having means for determining which in a plurality of signal strength bands the signal strength of a signal produced by a portable telecommunication apparatus and received by the base station lies, means for linking the portable telecommunication apparatus to the telephone network if the strength of the received signal lies within the strongest signal strength band, or otherwise recording an indication of the received signal in a pending received signal list, means for scanning through the communication channels for new signals from other of the portable telecommunication apparatus and recorded signals on the list, means for periodically increasing the band rank in which the recorded signals lie until they reach the highest signal strength band and then linking the originating telecommunication apparatus to the telephone network.

2. A telecommunication system according to claim 1 in which the base station includes means for

disregarding received signals of less signal strength than a lower predetermined signal strength.

3. A telecommunication system according to any one of the preceding claims in which the allocation of base stations to signals produced by the portable telecommunications apparatus is implemented by software incorporated in the base stations.

4. A telecommunication system according to any one of the preceding claims in which the base stations include means for deleting all signals on the pending list when setting up a link between a portable telecommunication apparatus and the telephone network.

5. A telecommunication system according to either of the preceding claims in which each base station includes means for scanning through the pending received signal list a predetermined number of times before deleting the list.

6. A telecommunication system according to any one of the preceding claims in which each base station includes means for deleting stored signals from the pending received signal list after a predetermined time.

7. A base station for communication with a telephone network and with a plurality of portable telecommunication apparatus through a corresponding plurality of communication channels, the base station having: means for determining which within a plurality of signal strength band, the signal strength of a signal produced by a portable telecommunication apparatus and received by the base station lies, means for linking the portable telecommunication apparatus to the telephone network if the strength of the received signal lies within the strongest signal strength band, or otherwise recording an indication of the received signal in a pending received signal list, means for scanning through the communication channels for new signals from the portable telecommunication apparatus and recorded signals in the pending received signal list, means for periodically increasing the band rank in which the recorded signals lie until they reach the highest signal band and then linking the originating telecommunication apparatus to the telephone network.

8. A base station according to claim 7 including means for disregarding received signals of less signal strength than a lower predetermined signal strength.

9. A base station according to claim 7 or claim 8 in which the allocation of base stations to signals produced by the portable telecommunications apparatus is implemented by software incorporated in the base stations.

10. A base station according to any one of claims 7 to 9 including means for for deleting all signals on the pending list when setting up a link between a portable telecommunication apparatus and the telephone network.

11. A base station according to any one of claims 7 to 10 including means for scanning through the pending received signal list a predetermined number of times before deleting the list.

12. A base station according to any one of claims 7 to 11 including means for deleting stored signals from the pending received signal list after a predetermined time.

13. A telecommunication system substantially as hereinbefore described with reference to the accompanying figures.

14. A base station substantially as hereinbefore

described with reference to figures 1,3 and 4 of the accompanying figures.